FINAL Public Release Report for the Boise Cascade Energy Savings Assessment (ESA-006):

1.1 Public Summary Report for the Energy Savings Assessment:

The following sections describe the findings and activities associated with the Training-Assessment. This description is a very brief overview. As a point of note definitions of some terms used in the characterization of projects is provided in the Definitions: section of this report.

1.1.1 Introduction:

The United States Department of Energy (U.S.DOE) Save Energy Now Program completed an Energy Saving Training-Assessment at the Boise Alabama Operations Paper Mill. Boise Alabama Operations is located in Jackson, Alabama. The onsite activities occurred December 19, 20 and 21, 2005. The principal investigator for the steam system assessment was Greg Harrell, Ph.D., P.E. from the Energy, Environment and Resources Center of The University of Tennessee Knoxville.

Boise Alabama Operations is a Kraft pulp mill supporting two paper machines. The paper machines produce general weight office type paper. The site is nominally designed to produce more than 1,000 ton/day of paper. The primary consumers of steam are the digesters, the bleach unit, the evaporators, and the two paper machines. Steam is supplied to the site from five boilers. One recovery boiler burning black liquor serves as the base steam supply component. One combination fuel boiler also serves as a primary steam producer. This boiler typically burns green wood and bark. The remainder of the steam production is provided by three power boilers (typically two are in operation). The power boilers are fired with natural gas.

The power boilers and the recovery boiler produce high-pressure steam at 650 psig and 740°F. The combination boiler produces intermediate-pressure steam at 350 psig and 605°F. Typically, the site steam production is nominally 650,000 lbm/hr.

The site is equipped with a backpressure extraction turbine coupled to an electric generator. The turbine generator set is nominally rated to produce 17 MW of electrical power. The turbine receives high-pressure (650 psig) steam. The extraction port discharges steam to the medium-pressure (150 psig) steam system and the final exhaust is to the low-pressure (55 psig) steam system. The nominal total site electrical demand is 62 MW. Therefore, the site is a net importer of the majority of the electrical power.

The J-1 paper machine is also equipped with a backpressure steam turbine operating the paper machine line shaft. The turbine has an approximate maximum power production capacity of 1.0 MW. This turbine operates between the 350 psig steam system and the 150 psig steam system.

Black liquor is the base fuel supplied to generate steam at the site. This fuel is considered a process byproduct with no direct steam system cost. Approximately 40% of the site steam production is generated by the recovery boiler. Wood and bark is also a base fuel for the site. Nominally, 20% of the site steam production is supplied from wood and bark. This is approximately 7% of the fuel cost for the site. The remainder of the normal steam supply (40%) is supplied by the natural gas fired power boilers. Natural gas is typically the impact fuel for steam system related projects. The natural gas fired boilers are operating within their functional capacity range. Natural gas is approximately 93% of the fuel related operating cost for the site.

1.1.2 Objective, Approach, and Focus of Energy Savings Assessment:

The Save Energy Now Energy Savings Assessment is designed to be an onsite *Training-Assessment*. The Training-Assessment places a system specific specialist onsite to evaluate the steam system, assess the operating performance of the steam system, and chart a course for operational and management improvement of the system. The primary strength of this activity is that site personnel are trained in the field evaluation techniques, modeling techniques, and implementation strategies associated with steam system management.

The U.S.DOE Steam System Evaluation Tools are used for the investigations and the site energy assessment team is trained in the use of the tools. These tools are software based and provide the site participants with powerful evaluation components to aid in system energy management. Furthermore, because replication is a primary focal point, it is a primary goal of the program to involve all interested personnel. Personnel from other sites are invited to participate in the Training-Assessment.

There are three primary goals of the Training-Assessment. The first goal is to identify realistic energy saving projects that will satisfy acceptable economic criteria for implementation. The target projects are fundamental in nature with low technical and financial risk. The second goal is to train site personnel in the evaluation techniques, management techniques, and practical applications of steam system management. This involves field measurement methodologies, U.S.DOE Steam Tools training, and general principles training. The third primary goal is to identify BestPractices that are in use at the site. This identification is designed to highlight excellent activities that are broadly applicable and can be replicated throughout the industry.

1.1.3 General Observations of Potential Opportunities:

The following sections of this report are intended to provide a brief description of the initiatives the site is pursuing to improve management of energy resources associated with the steam system.

1.1.3.1 Combination Boiler Tuning

Prior to the onsite Training-Assessment the combination boiler (green wood fired) was subjected to a combustion tuning process. Before the tuning event the boiler operated with flue gas oxygen concentrations in the 8% to 12% range (110% to 250% excess air). After the tuning event the flue gas oxygen concentration is maintained in the 6% to 7% range (70% to 95% excess air). This activity was completed by site engineers prior to the Training-Assessment with minimal expense. The green wood savings is approximately $70,000/yr. In general the minimum flue gas oxygen concentration of a stoker fired green wood boiler is 5%. Therefore, additional improvements in this area are not highly probable. The oxygen concentrations noted in this text are “wet basis” measurements. This is considered a completed opportunity.

1.1.3.2 Power Boiler Condensing Economizer

The natural gas fired power boilers operate with very good efficiency. The combustion process is well managed with the flue gas oxygen concentration in the 2% to 3% range (wet basis). The boilers are equipped with feedwater economizers that allow the flue gas to discharge with a temperature of approximately 320°F. As a result, the power boilers operate with very good efficiency. In the opinion of the assessor condensing economizers for moderate capacity and pressure industrial boilers are not proven in the mainstream. However, the efficiency of the boilers can be improved approximately 10% with the installation of a condensing economizer.

The energy savings opportunity is approximately $4,000,000/yr. It is grossly estimated that the purchase and installation of condensing economizers as additional heat recovery components for the boilers would require an expense of approximately $4,000,000. This gross cost estimate is based on the point that traditional economizers for the boilers could be installed for approximately $2,000,000 (all three boilers combined)—the boiler are currently equipped with these components.

The recommendation for this issue is to maintain contact with this emerging technology. The technology has been proven in small natural gas fired gas heaters, small natural gas fired water heaters, and small natural gas fired boilers. The technology has not been proven in industrial boilers but improvements are being completed in this arena and the benefits are significant. This is considered a long-term project that could reduce natural gas consumption by 10%.

1.1.3.3 Boiler Blowdown Thermal Energy Recovery

All of the boilers serving the site are equipped with the first stage of a blowdown thermal energy recovery system. The first stage systems incorporate flash steam recovery vessels that discharge flash steam generated from the blowdown stream to the 55 psig steam system. This is an excellent energy management activity that recovers approximately 40% of the thermal energy resident in the blowdown.

A significant amount of additional thermal energy can be recovered from the liquid blowdown rejected from the flash vessel. The recovery boiler is equipped with a shell-and-tube heat exchanger to accomplish this; however, the heat exchanger is out of service. If this heat exchanger is placed back into service the approximate savings is $70,000/yr. The repair cost associated with this heat exchanger is estimated to be less than $15,000.

If the second stage of blowdown energy recovery is installed on the remaining boilers the savings can increase approximately $100,000/yr. The purchase and installation cost of the heat exchangers is estimated to be less than $100,000.

The most appropriate type of heat exchanger for this service is one that can be periodically cleaned (the blowdown liquid has a significant fouling potential). Generally, heat exchangers that have been successful in this service are plate-and-frame heat exchangers and straight-tube shell-and-tube heat exchanges. These units allow cleaning of the majority of the heat transfer surfaces.

The blowdown stream could also be rejected to the mill water stream. This would eliminate the necessity of a heat exchanger and would reduce the steam requirements for heating the mill water. This would increase the energy saving more than $60,000/yr.

Even though the thermal energy recovery is from all of the boilers (recovery, combination, and power) the impact fuel will be natural gas. This results from the fact that the net result will be a decrease in steam demand (deaerator steam demand). The impact boilers are the power boilers for this site.

This is considered a medium-term opportunity. The natural gas savings associated with this initiative is approximately 0.5% of the total site consumption.

1.1.3.4 *Combination Boiler Steam Generation Capacity Increase*

Currently, the combination boiler operates with an average steam generation of 130,000 lbm/hr. The boiler has a nominal steam rating of 200,000 lbm/hr. The boiler currently operates with a maximum "average" steam generation of 171,800 lbm/hr. This maximum is a limit imposed by environmental restrictions. These restrictions are currently being challenged. Site engineers and operations personnel are monitoring flue gas emissions for the maximum boiler steam productions to prove the emissions are well below environmental restrictions. Once the operations are proven the boiler steam production will be increased to near the new environmental restriction.

Analyses indicate the economic impact of increasing the steam production of the combination boiler 10,000 lbm/hr is more than $1,000,000/yr. The cost of allowing the steam production of the boiler is expected to be minimal. Additional green wood supplies are available. This is a central focus of the steam system management activities. It should be pointed out that an increase in steam production from the combination boiler will reduce steam production from the natural gas fired boilers.

This is considered a medium-term opportunity. The natural gas savings associated with this initiative is approximately 2.7% of the total site consumption.

1.1.3.5 *Sludge Pelletizer Project*

Waste sludge from the paper manufacturing process is discharged from the system. The sludge contains approximately 50% liquid water—the remainder of the material is primarily cellulose material. Discharging the material to a landfill is not desirable and is an expense to the site. As a result, the material is burned in the combination boiler. The material does supply a net amount of energy to the boiler. However, the energy release is minimal because of the large amount of liquid water in the sludge and the tendency to load the boiler with slugs of the material. Loading slugs of the material disrupts the combustion zone characteristics of the boiler.

A trial has been initiated to investigate the benefits of pelletizing the sludge to reduce the liquid water concentration and to improve the handling characteristics of the material. The pelletizing equipment will reduce the liquid water concentration to less than 20% of the total mass of the material. Supplying this material to the combination boiler will increase steam production from the combination boiler for the same fuel flow through the boiler. This will allow the natural gas fired boiler to reduce steam production an equivalent (energy) amount.

The economic benefit of pelletizing 50 ton/day of paper mill sludge is approximately $200,000/yr. The pelletizing equipment is supplied with a lease agreement. The cost of the pelletizing equipment lease and the electrical energy required to operate the equipment is $100,000/yr.

This is considered a near-term opportunity. The natural gas savings associated with this initiative is approximately 0.5% of the total site consumption.

1.1.3.6 *Recovery Boiler Soap Fuel System*

One of the most important avenues for improving the management of the economic factors of the steam system is to increase the steam production of the recovery boiler (black liquor boiler). The boiler is designed with more capacity than is currently being utilized; however, fuel supply limitations and process decisions restrict the amount of black liquor burned in the boiler. Site process engineers are actively challenging these issues.

The site produces soap as a byproduct of the pulping process. The soap can be converted to tall oil and sold or it can be burned as a fuel in the recovery boiler. A system that allows the combustion of the soap in the recovery boiler has been installed. This has resulted in the purchaser of the material dramatically increasing the purchase price (approximately a factor of three). Therefore, the material is not being burned in the recovery boiler but the economic benefit to the site is approximately $1,000,000/yr. An additional $200,000/yr savings could be attained by burning the material in the recovery boiler.

It should be noted that this activity has not been completed as a part of the Training-Assessment but is highlighted as a recent activity that has dramatically affected the energy management of the site. This is considered a completed opportunity.

1.1.3.6.1 *Recovery Boiler Steam Generation Capacity Increase*

There are several avenues that are being explored to increase the steam production from the recovery boiler. In general the primary candidates involve supplying more black liquor to the boiler. This will in general require additional levels of combustion air or significant modifications to the boiler. All of these modifications will subject the recovery boiler to environmental review and possible re-permitting issues. These are major issues to overcome. This is considered a long-term opportunity. The natural gas savings could be approximately 3%.

1.1.3.7 Backpressure Turbine Operation

The current impact fuel and impact electrical costs for the site result in a situation where it is economically unattractive to operate the backpressure steam turbine generator. Site engineering personnel are monitoring the situation and are managing the operation of the turbine equipment appropriately. The turbine will be placed into service when the economic conditions change to a more favorable situation.

1.1.3.8 Coal or Coke Fired High-pressure Cogeneration

Because of the large thermal energy requirement of the Kraft pulp and paper process the facility is an excellent candidate for coal or coke fired high-pressure steam cogeneration system operation. A backpressure extraction turbine cogeneration system of this nature could produce an economically attractive project for this site. However, the timeframe of the project is beyond three years. As a result, this arena received only cursory investigation. It should be noted that coupling a pulp and paper facility with a coal fired modified Rankine cycle power generation system presents a high-efficiency system.

1.1.3.9 Insulation Repair

The thermal insulation throughout the site is observed to be in good condition. The piping is generally appropriately insulated with adequate jacketing. However, there are several pipes observed to have missing insulation. Site operations and maintenance personnel has completed preliminary surveys identifying areas of missing insulation. The items noted during the Training-Assessment represent a savings potential of $80,000/yr. The estimated re-insulation cost is approximately $25,000.

One project included in this list is the feedwater supply piping to the deaerator. There is more than 500 feet of 8 inch nominal diameter piping that is un-insulated. The feedwater in this pipe is approximately 160°F. Insulating this pipe will reduce energy losses approximately $40,000/yr. The insulation investment is estimated to be $12,000. This emphasizes the point that with the current elevated fuel costs even relatively low-temperature piping can be insulated with an attractive economic return.

This is considered a near-term opportunity. The natural gas savings associated with this initiative is approximately 0.2% of the total site consumption.

1.1.3.10 J-3 Paper Machine Condensate Recovery

The J-3 paper machine is supported by many heat exchangers. Two of the heat exchangers are the mill water heat exchanger and the process water heat exchanger. These heat exchangers experience continuous operation and significant 150 psig steam demand. The condensate discharge and collection system supporting the heat exchangers is not functioning because of equipment failures exacerbated by design issues. This results in the discharge of approximately 100 gal/min of condensate to the sewer.

The condensate collection system is served by pressure powered pumps that are not functioning. The condensate discharge system is currently connected to the main paper machine cascade condensate collection system. Complete replacement of the condensate collection system serving this system would require an expenditure of $300,000. The energy benefit associated with returning 100 gal/min of condensate to the boilers is approximately $800,000/yr. Therefore, significant effort should be given to this issue.

This is considered a medium-term opportunity. The natural gas savings associated with this initiative is approximately 2.2% of the total site consumption.

1.1.4 Management Support and Comments:

All of the support provided for this activity was exceptional. The Training-Assessment was well planned and preparations were excellent. It is notable that the site has initiated a Charter Team that is focused on energy. This team is composed of engineering, operations, and maintenance personnel with significant knowledge in aspects of the steam system. This team has accomplished substantial improvement in the management of the steam system.

1.1.5 Potential Case Study Opportunities:

A potential case study could be provided in the operation and management of the backpressure steam turbine generator unit. The economic conditions of this site provide situations where it is economically attractive to operate the backpressure turbine and conversely where it is not economically attractive to operate the backpressure turbine.

Also, a case study could be provided relating to increasing the steam generation capacity of the boilers that produce steam from significantly lower cost resources. This allows the steam production from natural gas to be reduced.

1.1.6 DOE Contact at Plant/Company:

The primary contact at the plant site is Matt Davis, Energy Engineer, (251) 246-8597, mattdavis@boisepaper.com.

1.1.7 Definitions:

Recommendations are identified on the basis of the timeframe of the most probable completion. One of three designations is assigned to each recommendation—*near-term opportunity, medium-term opportunity*, or *long-term opportunity*.

A *near-term opportunity* would include actions that could be taken as improvements in operating practices, maintenance of equipment, relatively low cost actions, or low cost equipment purchases. Completion of a near term opportunity can easily be attained in less than one year. Examples of near-term opportunities are boiler combustion tuning, general insulation remediation, preferentially operating a backpressure steam turbine rather than an electric motor drive, and initiation of a steam trap management program.

A *medium-term opportunity* would require purchase of additional equipment and/or changes in the system. It would be necessary to carryout further engineering and economic analysis. Completion of the opportunity could be attained in the one to two year timeframe. Examples of medium-term opportunities are the addition of automatic combustion control equipment, the installation of a blowdown thermal energy recovery system, the installation of a feedwater economizer, and the installation of a condensate and flash steam recovery system.

A *long-term opportunity* would require testing of new technology and confirmation of performance of these technologies under the plant operating conditions with economic justification to meet the corporate investment criteria. Completion of the opportunity could be attained in the two to five year timeframe. Examples of long-term opportunities are the evaluation of process drive components to determine if a steam turbine should be installed and the evaluation of an opportunity to replace an energy resource requirement with steam.